Lectures by

George E. Mueller

Associate Administrator for Manned Space Flight
National Aeronautics and Space Administration

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Lecture I

THE U.S. SPACE EFFORT

The exciting era of space flight began on October 4, 1957 with the launch of the first man-made satellite by the Soviet Union. The earth orbital flight of Sputnik I dramatized the potential of space exploration and its impact added urgency and impetus to all U.S. efforts toward unmanned and manned space flight.

The advances of the U.S. manned programs in less than a decade since the first Sputnik will be discussed in this lecture series. Lectures will be devoted to the manned flights of the U.S. Mercury and Gemini programs already completed, and to the role of the Apollo program in furthering the development of manned space flight capability to be demonstrated in the Apollo lunar mission. Finally, the values and worth of present and future space exploration will be placed in perspective.

UNMANNED PROGRAMS

No such perspective of space exploration is possible, however, without recounting the remarkable accomplishments achieved in space thus far through the use of unmanned satellites and spacecraft, beginning with the limited exploratory probes begun more than 20 years ago.

One of the interesting early experiments conducted in the U.S. took place in 1946, when a captured V-2 rocket was launched from White Sands, New Mexico to an altitude of 55 miles, and obtained the first spectrum of the sun in the far ultraviolet. Radiation in the ultraviolet and a number of other regions of the spectrum is largely absorbed by the earth's atmosphere.

Rockets have been launched at increasing rates since 1946 on suborbital flights to explore the upper atmosphere, to make weather observations, to explore the region of space near the earth, and to make astronomical observations.

Since 1957, man has been able to employ rockets to launch satellites about the earth and, since 1959, he has been able to use them to overcome the earth's gravity and send instrumented spacecraft out into interplanetary space.

Near-Earth Exploration

The first major scientific advance resulting from this ability was the discovery of the radiation belts surrounding the earth. The first United States satellite, Explorer I, launched January 31, 1958, detected radiation of such intensity that it swamped the instruments that were intended to measure the cosmic rays. Another satellite, Explorer III, was launched less than two months later with instruments calibrated differently. Dr. James A. Van Allen of the State University of Iowa announced the discovery of the radiation belts before the National Academy of Sciences on May 1, 1958.

Another interesting early finding is related to the shape of the earth. We are all taught that the earth is an oblate spheroid -- generally round but with a somewhat greater diameter at the equator than at the poles. It was believed until a decade ago that the ratio of the oblateness was 1/197. However, careful study of the orbit of the Vanguard I satellite, launched in 1958, showed that the fraction is 1/298.2. Further analysis showed also that the southern hemisphere is a little more oblate than the northern hemisphere. The difference is about 100 feet. The sea level in the Arctic Ocean is 50 feet higher than expected, and 50 feet lower around Antarctica. In other words, the earth is just a bit pear shaped.

Exploration Beyond Earth

Much of the emphasis of our unmanned satellite programs in succeeding years has been to learn in detail about the earth and its relationship to the Sun, and to explore the moon, Venus and Mars, and interplanetary space, and to provide practical applications. We should keep in mind, however, that it has been necessary to employ military rockets adapted for the purpose. It is only now that launch vehicles designed from the beginning for space flight are coming into use.

Study of the earth focuses on the atmosphere, the ionosphere and the magnetosphere. To learn about the sun, instruments are pointed to observe the corona, the chromosphere and the disc itself, with particular attention to flares, solar storms and sunspots.

Lunar Exploration

Another area of special interest is the exploration of the moon. In 1964 and 1965, three Ranger spacecraft were launched to impact the moon, taking pictures continually during the final minutes of flight (Figure 1). Altogether more than 20,000 pictures were obtained, indicating that a significant percentage of the moon's surface is acceptable for landing sites insofar as topography is concerned. The Ranger IX transmissions were seen live on television here on earth.

Next in our unmanned lunar program was Surveyor. In 1966, the first Surveyor accomplished a successful soft landing on the moon and returned more than 10,000 photographs indicating that this particular spot is suitable for a landing (Figure 2).

The third program, which also began in 1966, is the Lunar Orbiter, designed to gain additional photographic information on potential landing sites (Figure 3). The Lunar Orbiter flights are scheduled to continue through 1967.

Planetary Exploration

In the exploration of the solar system we have conducted flights past the two nearest planets, Venus and Mars, as well as several through interplanetary space. In 1962, Mariner II passed 21,500 miles from Venus after a journey of 109 days and transmitted information about the planet across a distance of 36 million miles. The most important finding was that the atmosphere of Venus is hotter than previously believed. Temperature readings of 600 degrees Fahrenheit were obtained.

In 1965, Mariner IV traveled 228 days and passed within 7,400 miles of the planet. Over a distance of 134 million miles, Mariner IV transmitted to earth 21 clear photographs, which indicated that the surface is cratered like that of the moon (Figure 4). Radio signals sent when Mariner passed behind Mars showed that the planet's atmosphere is thinner than expected.

Data transmitted failed to supply evidence of a dust belt, a magnetic field or radiation belts.

Spacecraft in the Pioneer series have measured particles and fields in interplanetary space up to distances of more than 50 million miles.

Applications of Space Technology

In earth orbit, unmanned spacecraft have been employed with great success to develop, demonstrate and begin operation of practical applications of space technology. The most advanced of these applications are in weather, communications and navigation.

In meteorology, there have been two unmanned spacecraft programs, TIROS and NIMBUS. The TIROS series consisted of 10 successful satellites orbited between 1960 and 1965, photographing cloud cover, obtaining infrared measurements and transmitting the results to earth. As I feel sure is well understood here in Australia, the weather originates to a large extent in the five-sixths of the earth's surface covered with water, where weather stations on the surface are few and far between. Consequently, photographs of a developing storm system or typhoon from a satellite provide timely warnings that can prevent losses of life and property. In addition, the infrared readings enable us to understand the earth's energy balance. Beginning this year, the U. S. Department of Commerce has had an operational system of weather satellites similar to those in the TIROS series.

One of the limitations of TIROS is that its orientation is constant with respect to space. Thus it points to the earth only during half of earth orbit. In addition, the orbits have been inclined, so that the satellites do not pass over the polar regions where some of the most interesting weather is found. To overcome these limitations, we are now flying the NIMBUS satellites, which are larger, constantly pointed toward the earth, and are launched from California into near-polar orbits.

As many of you may know, a station has been constructed at the University of Melbourne to receive TIROS and NIMBUS photographs, which should make a very real contribution to the advance of meteorology here in Australia. Two other stations are being constructed at Darwin and Perth, also.

In communications, a number of experiments have been carried out successfully, beginning in 1960 with the Echo balloon satellite and later with Telstar, Relay and Syncom. In principle, a communications satellite acts as a tall antenna tower, which enables us to transmit beyond the horizon as seen from the surface. The Syncom satellite demonstrated that it is possible to station a transmitting antenna at an altitude of 22,000 miles. At this altitude, the spacecraft maintains its position above a fixed point on the Equator, since its period of rotation is 24 hours.

This orbit is also used by the Early Bird satellites of the Communications Satellite Corporation, the first commercial venture in space, which is now supplying telephone and television communications between the United States and Europe.

A third application now operational is navigation by satellite. The U. S. Navy Transit satellites now supply all-weather navigation services to units of the fleet.

Relationship Between Unmanned and Manned Programs

It should be emphasized that an intimate interrelationship exists between the NASA unmanned and manned programs. While our attention will be focused on manned flights, we should be aware of the complementary role of the unmanned missions. The unmanned scientific investigations of the earth, moon, sun, planets, stars, galaxies and outer space invariably support advances in the manned programs. Some of these, such as the recent Surveyor mission, are essential forerunners of specific manned flights. The experiments of manned flights, in turn help to increase the body of knowledge concerning the phenomena of space and our quest for earthly applications of this knowledge.

The manned programs, concurrently, have made possible and in a sense, have demanded the successive advances in manned space capability achieved continuously from the first Mercury missions. The tasks that man can perform are expanding with this increased capability, which can be measured almost from flight to flight. Considered with the incredible growth of human knowledge on all fronts, the ultimate role of man, working in the extraterrestrial environment, is virtually beyond prediction.

THE SPACE ENVIRONMENT

In building its programs of space flight and exploration, NASA has assigned a key role to man. He is not merely a passenger on a space vehicle, but an important element in the man-machine complex. He is a point of decision and command, an experimenter, and a source of intelligent reporting and interpretation of things seen and done. He is a sensor, a manipulator, an evaluator, and an investigator.

The conditions of his flight into space therefore must be such that he not only survives but maintains the efficiency level needed to participate in many essential activities.

Man's survival in space depends upon achieving two basic conditions - a habitable environment and protection against the physiological stresses and incidental hazards of space flight and the space environment.

Life Support Requirements

On earth, man functions in a gaseous environment consisting of about 20 percent oxygen and 80 percent nitrogen at a total pressure of 14.7 pounds per square inch at sea level. He is, however, quite an adaptable mechanism and he can function in other atmospheres, although his range of adaptability does not accommodate survival in the vacuum of space. It is, therefore, necessary for him to take his environment with him into space.

Stresses of Space Flight

Sustaining life in the space environment is not alone a matter of providing a habitable atmosphere and taking care of the metabolic needs of man. In addition, he must be protected from the physiological effects of environmental factors incidental to space flight. These factors include noise, vibration, acceleration, and impact, weightlessness, isolation, confinement, and altered diurnal cycles.

Weightlessness

Prior to the Mercury and Gemini flights, very little was known concerning the effects of prolonged weightlessness on man. This was because except for very brief periods, there were no methods by which this condition could be realistically simulated on earth. Our lack of ability to simulate weightlessness and the consequent lack of information available concerning its effects, led to its being regarded as one of the critical potential problems limiting man in space travel. The Gemini flights demonstrated that it was not nearly the problem it had been anticipated for flights of this type.

THE ROLE OF MAN IN SPACE

Despite the hostility of space to man, the feasibility of his role in this alien environment already has been convincingly demonstrated. As I have noted, the means of providing a habitable environment has been established for the requirements of flights presently being undertaken, and the capability for attenuation of foreseeable hazards and potential hazards continues to develop.

Motivation for Manned Exploration

The nature of man to explore the far reaches of his earthly environment has been amply documented by his successive accomplishments throughout history. Space exploration is but a new level of achievement in probing and exploiting the unknown. The thrust of mankind to master the barriers of mountains, then oceans, and finally the atmosphere, has proceeded to the ocean of space. The curiosity, courage, and adventurous determination which has characterized all of men's previous advances in the mastery of his environment are now being brought into play in the scientific, technological and operational gains of the U.S. space effort.

EARLY ROCKET TECHNOLOGY

Man's conquest of space is based upon the utilization of rocket thrust. Prominent in the background of the U.S. space program is the early rocket technology which served as a forerunner to the development of the launch vehicles which are essential to all space endeavors.

The U.S. manned space flight program incorporates a broad range of technology which emerged from previous programs dating back to early rocket research. Among these contributing national efforts were aircraft programs, ballistic missile development programs, aerospace medicine research, and the development of rocket technology in general, which is the basis of all space flight.

The pioneers of the scientific exploration of space were aware of the practical application of rocket propulsion for space flight. Men such as Konstantin E. Tsiolkovsky of Russia, Robert H. Goddard of the U. S. and Herman Oberth of Rumania and Germany, had published works early in the twentieth century contributing to space technology.

Goddard's Work

The foundation in rocketry laid by Dr. Robert H. Goddard are now widely recognized. As early as 1914, he was granted two patents which developed his ideas of a multi-stage rocket and liquid propellants. During this period, by static laboratory test, he proved his theory that a rocket would perform in a vacuum and was therefore capable of operating in space.

His experimentation in rocketry continued unceasingly from 1917 until his death in 1945. During 1920 he began his pioneering experimentation with liquid-fuel propulsion, considering an idea for a hydrogen and oxygen fuel supply he had conceived as early as 1909.

He accomplished the first liquid-fuel rocket flight in history in March 1926.

During the 1930's he performed numerous rocket flight tests in New Mexico, as he continued to develop the science of rocketry. With his lifetime of effort in this field, Dr. Goddard demonstrated all of the fundamentals for successful rocket flight, covered by more than 200 patents. They range from fuels, multi-stage design, guidance and control, to payloads.

V-2 Missiles

Goddard's work went virtually unnoticed in the United States, even into World War II. In Germany, however, liquid-fueled rocket study had proceeded during the 1930's and by 1944 the German V-2 ballistic rockets were being launched from Germany against Britain. In basic design, the supersonic V-2 with its 200-mile range was almost identical to Dr. Goddard's much smaller liquid-fuel rocket.

POSTWAR DEVELOPMENT

Interest in rocket technology gradually developed in the United States following World War II, largely because of the impact of the German V-2 rocket on American military and scientific observers. The full realization of Dr. Goddard's contribution was to follow after a growing awareness of his experiments.

U.S. Rocket Research

The potential of large rockets demonstrated by the V-2 missiles gave increased impetus to plans for exploring the realm of space with instrumented, and eventually manned, rocket vehicles. The U.S. armed services pursued several rocket projects in the postwar period, using V-2 components and adaptations of the V-2 engines, as well as other engine developments. By 1949, the Navy had developed a more powerful rocket, the Viking, for high altitude atmospheric probes. By 1952 the National Advisory Committee for Aeronautics (NACA) was devoting a modest amount of effort to studies looking forward to manned space flight. The X-15 rocket research airplane project carried out jointly by the NACA and the Air Force began in 1952. The U.S. intercontinental ballistic missile program was begun in 1954, leading to the development of a new generation of rocket systems with the great thrust needed for military payloads.

PROJECT VANGUARD

The first United States earth satellite program was project Vanguard, initiated in 1955 under the management of the Naval Research Laboratory. Its purpose was to develop a satellite-launching vehicle and tracking system, and to place at least one satellite in orbit with an experiment payload during the International Geophysical Year beginning July 1, 1957.

Impact of Sputnik Launch

On October 4, 1957 the Soviet Union Sputnik was launched, while flight tests of the Vanguard rocket stages were in progress. The impact of Sputnik was amplified further by the launch of Sputnik II a month later. The Army Ballistic Missile Agency's satellite proposal was revived and activated as a backup to Vanguard and the Advanced Research Projects Agency was formed to take charge of all Department of Defense space programs.

Vanguard and Explorer Satellites

The launch of the first Vanguard rocket with potential orbit capabilities was attempted on December 6, 1957. The launch failed when the first stage engine lost thrust 2 seconds after ignition, and the vehicle burned up on the pad. The launch of the first U. S. satellite, Explorer I, was accomplished by the Army Ballistic Missile Agency on January 31, 1958. After a second unsuccessful Vanguard launch attempt in February of 1958, the first Vanguard satellite was launched into orbit on March 17, 1958.

ESTABLISHMENT OF NATIONAL SPACE AGENCY

Following the success of the Soviet Union in orbiting Sputnik, the President and the Congress of the United States began a careful and detailed review of the national competence and potential in the interdependent areas of missile and space development.

Early in 1958, the President's Advisory Committee on Government Organization recommended that a civilian space agency be established, patterned after the successful National Advisory Committee for Aeronautics. The President's Science Advisory Committee soon after urged national action to develop space technology.

National Aeronautics and Space Administration

In March 1958 the President approved his advisory committee's recommendation that a civilian space agency should be created upon the structure of the existing National Advisory Committee for Aeronautics, and that this agency should have responsibility for all non-military space activities in an integrated program. A space agency bill reflecting these recommendations was proposed by the President and sent to the Congress. The House and Senate special committees immediately considered the proposed bill in their hearings.

The result of these deliberations was a national decision involving the President, the Congress, and the American public. The decision was embodied in the National Aeronautics and Space Act of 1958, signed by the President on July 29, 1958. The agency created by the Act to carry out a mandate for a national civilian space effort was the National Aeronautics and Space Administration (NASA).

National Objectives In Space

In addition to creating a national space agency, the legislation provided the objectives which were to be the guide for all national space efforts in the future (Figure 5). The objectives in brief were (1) the expansion of human knowledge; (2) improvement of aeronautical and space vehicles; (3) development and operation of space vehicles; (4) long-range studies for peaceful and scientific use of aeronautics and space; (5) international cooperation; and (6) effective utilization of resources.

CONSOLIDATION OF SPACE EFFORT

NACA Nucleus of New Agency

The new space agency was formed by using the National Advisory Committee for Aeronautics as the nucleus. Eight thousand NACA personnel, including scientists, engineers, and technicians were transferred to NASA. Facilities of NACA absorbed by NASA included the Langley, Ames, Lewis, and Edwards Research Centers, with their 40-year legacy of NACA aeronautical, rocket propulsion and missile research.

Transfer of Non-Military Space Projects

Army, Air Force, Navy and Department of Defense nonmilitary space projects also were transferred to NASA. Integrated with this move were the space probes, satellites, and rocket engine programs of the services. Among the projects and personnel acquired were the Project Vanguard scientific satellite program and 200 highly qualified scientific and technical personnel from the Naval Research Laboratory.

By the end of 1958, the Jet Propulsion Laboratory of the California Institute of Technology, previously under contract to the Army, was brought under NASA direction. At the same time, the Army Ballistic Missile Agency at Huntsville, Alabama was made responsive to NASA requirements. The large liquid fueled Saturn rocket program at Huntsville, initiated in 1958 under Department of Defense auspices, also became responsive to NASA direction.

In mid-1960, this group of rocket experts of the

Army Ballistic Missile Agency's Development Operations Division, and their facilities, were transferred to NASA. With the transfer, the George C. Marshall Space Flight Center was established.

The NASA Launch Operations Center at Cape Canaveral also was established in 1960 and became an independent NASA Center in July 1962. It was renamed the John F. Kennedy Space Center in November 1963 in honor of the late President, concurrent with the redesignation of Cape Canaveral as Cape Kennedy.

Manned Space Flight Capability

Specific capabilities for manned space flight were created by this organizational alignment of the U.S. space exploration projects. Efforts which had been fragmented came together under the new space agency, each contributing to the total national program.

Key personnel from several laboratories of the National Advisory Committee for Aeronautics were transferred to the Langley Research Laboratory. They later became the nucleus for the Project Mercury team which eventually expanded to become the Manned Spacecraft Center at Houston, Texas.

The project Vanguard team formed the nucleus of the new Goddard Space Flight Center at Greenbelt, Maryland, concentrating on unmanned satellites and spacecraft, and creating the basis for the worldwide Goddard tracking and communications network. This network was later expanded and refined to support both unmanned and manned space flight and, in addition, supplied expert personnel for other NASA activity.

The rocket development team from the Army came to provide the large booster support for advanced manned flight. The efforts of the military services were drawn upon heavily to provide the early rocket boosters, as well as launch facilities and crews, and recovery support for manned space flight.

With the capability created through consolidation of people and projects in NASA, the new agency was able to proceed without delay on the programs for U.S. manned space flight, beginning with Project Mercury.

MANNED SPACE FLIGHT PROGRAMS

Project Mercury had its origins in study effort accomplished by and for the Air Force and the National Advisory Committee for Aeronautics. Its specific origin was the recommendation of a committee formed in September 1958, composed of representatives from the Department of Defense and the National Advisory Committee for Aeronautics, immediately prior to the official birth of NASA. The National manned satellite program which it recommended, named Project Mercury by the end of 1958, was approved by the NASA Administrator on October 7, 1958 and the project was immediately set in motion.

During Project Mercury, NASA's planning for the future pointed to manned exploration of the moon and the nearby planets as a goal of the indefinite future beyond 1970. In July 1960, following a Congressional committee recommendation for a high priority manned lunar landing program, NASA announced that the successor to Project Mercury would be Project Apollo. Its goal, however, was to carry three astronauts in sustained earth orbital or circumlunar flight. Plans for an eventual manned lunar landing were to be studied.

In May 1961, President Kennedy recommended to Congress an expanded national space program with the major accelerated goal of "landing a man on the moon and returning him safely to earth, during this decade." Congress subsequently endorsed the plan for expanding and accelerating Apollo including the development of spacecraft, large rocket boosters, and unmanned explorations which would support the Apollo objectives.

Meanwhile, in December 1961, the decision was taken to extend the manned space flight effort beyond Mercury providing an interim program before the flights of Apollo hardware could begin. This program, utilizing a two-man spacecraft, was officially named Gemini, after the third constellation of the zodiac with twin stars Castor and Pollux, in January 1962.

Major milestones for the Gemini and Apollo programs later were established, from the first Gemini flight scheduled for 1964 to Apollo operations scheduled for 1969 (Figure 6).

In my next lecture of this series, I will discuss the program philosophy of the first U.S. manned space flight program--Project Mercury--and will measure the accomplishments of Gemini against its program objectives. In so doing, I hope to provide an insight of some of the lessons we have learned concerning man in space.